

Feasibility of Mangrove Forest Products as Fabric Natural Dyes in Garut Regency

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(Received: November 25th, 2022; Accepted: November 29th, 2023)

ABSTRACT

*Mangrove forests have tangible and intangible benefits, but mangrove deforestation and degradation in Indonesia are relatively high due to economic reasons. Mangroves can contribute economically by considering social and economic characteristics, such as natural dye on traditional fabrics. Unfortunately, studies on mangroves' potential as a natural fabric dye and their relationship with social and economic potential are limited. Therefore, this study aimed to analyze the feasibility, prospects, and challenges in developing natural dyes from mangroves for traditional fabrics. Through field observations in the Leuweung Sancang Nature Reserve in Garut Regency, interviews, and literature studies, this study used a descriptive approach with SWOT and financial analysis. At least three mangrove species can be used as natural dyes to produce brown color variants: *Bruguiera gymnorizha*, *Rhizophora mucronata*, and *Rhizophora apiculata*. The strategic location, with an intense fabric industry and high community motivation, provided opportunities to develop mangrove dye products. The business was feasible and resistant to the economic crisis. However, even though the community knows the mangrove benefits of natural fabric dyes, there was no development practice because of no assistance in processing. Supports from the government, forestry extension agents, NGOs, and universities are essential for mangrove conservation while improving livelihood and economic welfare through the mangrove natural dyes business.*

Keywords: economic potential, mangrove, natural colorings, traditional fabric,

INTRODUCTION

Mangrove forests are communities of plant species that grow in tidal seawater areas in shallow intertidal and subtidal areas in tropical and subtropical tidal swamps. The mangrove ecosystem in Indonesia grows about 3 million hectares along 95,000 kilometers, which means 23% of the world's overall mangrove ecosystem (Giri et al., 2011). In addition to tangible benefits, mangrove forests provide intangible benefits such as resisting seawater intrusion, tourist services, and carbon pools. Mangrove

forests store the densest carbon content in tropical regions, which is about three times the average carbon per hectare more than in mainland tropical forests (Donato et al., 2011). Indonesia's mangrove forests store 3.14 billion metric tons of carbon (Murdiyaso et al., 2015), accounting for one-third of the global coastal carbon stock (Pendleton et al., 2012). However, mangrove ecosystems in Indonesia have lost 40% of the total area of these ecosystems over the past three decades, one of which is due to the need for land use for economic factors (FAO, 2007).

On the other hand, mangrove plants are known to have potential social and economic value for the scale of household and industrial interests, for example, as a natural dye in batik and woven fabrics, a traditional Indonesian fabric industry. *Kementerian Koordinator Bidang Perekonomian* or The Coordinating Ministry for the Economy (2011) stated that the entire fabric product industry has a workforce of 1.3 million people, and in 2007 it contributed foreign exchange and national products worth IDR 90 trillion. The traditional fabric product industry is included in the fabric industry, which is essential for Indonesia (Mahadewi, 2015).

The colors in traditional Indonesian fabrics are very diverse but still use synthetic dyes that can produce large amounts of waste and pollution to the environment. Nowadays, the global fabric industry employs about 98 million tons of non-renewable materials every year, one of which comes from synthetic fabric dyes. The carbon footprint of the fabric industry includes 1.2 billion tons of CO₂ released into the atmosphere. As well as, liquid waste from the dyeing process of the fabric industry becomes a source of world water pollution (17-20%), which causes the water to become cloudy and its quality to decline (Ellen MacArthur Foundation, 2017; Jain & Vasantha, 2016; Ogugbue & Sawidis 2011). This increase in water turbidity can prevent the entry of sunlight below the water's surface, thereby causing the depletion of dissolved oxygen and the death of living beings (Pujilestari, 2015). In addition to negatively impacting the environment, synthetic dyes also negatively impact the health of their users because the harmful chemicals, such as carcinogenic, can trigger cancer (Lacasse & Baumann, 2012), allergic dermatitis, skin irritation (Sivarajasekar & Baskar, 2014), local sarcomas and tumors in the liver, bladder (Pohanish, 2017). Based on the negative impact caused by synthetic dyes on the fabric industry, alternative solutions are needed as substitutes in the fabric dyeing process.

Considering the negative impacts of synthetic dyes on the environment and human health, natural dyes can be an alternative

substitution. Natural dyes are safe to use, renewable, and easily degraded. Natural dyes are generally derived from plants and can be well decomposed by the soil because they are of organic matter. Some parts of plants that contain natural coloring agents are mangrove propagules which are fruits, roots, wood, and mangrove branches.

Leuweung Sancang Nature Reserve in Garut Regency has a reasonably good mangrove ecosystem. Still, the threat of mangrove damage remains if it is not balanced with an increase in the community's economic welfare. Therefore, with the potential for mangrove conservation through environmentally friendly economic activities, this research aims to identify the potential of mangroves for business feasibility and their development challenges. On the other hand, research on natural fabric dyes is only related to chemical content and manufacturing techniques. Meanwhile, research on the social and economic aspects of natural mangrove coloring for traditional Indonesian fabrics is still minimal. Therefore, this research is critical to explore the potential of mangrove forests in environmentally friendly and sustainable economic efforts.

METHODOLOGY

Data Collection

Data is collected through field observations, interviews, and literature studies. Field observations were carried out in the mangrove forest of West Sancang District, Garut Regency, West Java Province, from June to July 2019. Semi-structured interviews were conducted with 15 respondents who are people of Sancang Village who often do activities in mangrove forests. Meanwhile, in-depth interviews were conducted with five local community leaders. For strengthening information related to natural fabric dyes, in-depth online interviews were conducted with the Kalpataru Environmental Service Category winners in 2019 and 2020, from the Yayasan Gajah Sumatera in Medan and the Tancang Jaya

Group in Kendal for their services in preserving mangrove ecosystems.

Data Analysis

This research uses a combination method approach between descriptive and exploratory research. Information and quantitative and qualitative data are analyzed descriptively. Furthermore, the Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis was used to map various possibilities and alternative solutions to developing non-timber forest products from mangroves as natural fabric dyes. Consideration of economic potential through financial feasibility analysis using the Discounted Cash Flow (DCF) method with a factoring discount of 7% following the interest rate on people's business loans for 20 years, as well as using the eligibility criteria of Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR) with the following equations:

$$NPV = \sum_{t=0}^n \frac{B_t - C_t}{(1+r)^t}$$

$$BCR = \frac{\sum_{t=0}^n \frac{B_t}{(1+r)^t}}{\sum_{t=0}^n \frac{C_t}{(1+r)^t}}$$

$$IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1)$$

Information :

NPV = Net Present Value

BCR = Benefit Cost Ratio

IRR = Internal Rate of Return (%)

Bt = Benefit

Ct = Cost

I = Interest (%)

n = Total of Business Time

t = Time to spend costs and benefit, t = 1,2,3,...

The business is feasible if the NPV is greater than zero and the BCR is greater than 1. The IRR is the discount rate in which the NPV of costs (negative cash flow) investment is equal to the NPV of benefits (positive cash flow) investment (Gregersen & Contreras, 1979).

In financial analysis, based on information from key informants who have tried to work on

batik from natural mangrove dyes, the following assumptions are used:

1. The batik business with the natural coloring of mangroves analyzed is on a household scale, with a production of 150 pieces per month
2. The selling price of written batik with natural dye of one-color mangroves is IDR 270,000.00
3. For batik coloring, one sheet requires 2 kg of mangrove propagules, equivalent to 30 unit of dry propagules. The price of propagules per fruit is generally IDR 100.00
4. The wage or service of laying cloth per sheet is IDR 100,000.00, and labor services for the dyeing process until the finished fabric is IDR 50,000.00 per sheet.
5. Other cost components are information from key informants considering the market prices of current batik fabric materials and equipment.
6. The discount factor is 7%, following the interest rate on the People's Business Credit (*Kredit Usaha Rakyat*) for 20 years.

RESULTS AND DISCUSSION

Conditions and Potential of Plants in Leuweung Sancang Nature Reserve

The Sancang area was designated as a nature reserve and wildlife sanctuary on July 1, 1959 (Decree of the Minister of Agriculture Number: 116/Um/1959), with a sea area of around 150 ha. Sancang Forest is a natural forest located in the southern part of Garut Regency (bordering Tasikmalaya Regency), precisely in Sancang Village, Cibalong District. Natural forests are protected nature reserves with tropical rainforest ecosystems. Sancang Forest has an area of ± 2,157 ha with an altitude of 0-3 m above sea level. In addition, the area has cliffs on the part of its coastline, the general configuration of the soil is flat, and the average temperature is between 17°C-28°C (Rosyadi, 2013).

Leuweung Sancang Nature Reserve has a relatively good mangrove forest ecosystem. The

mangrove preservation is likely to be influenced by history and myths related to the ancestors of West Java and is also considered sacred by the local community. Kaboa trees or black mangroves (*Aegiceras corniculatum*) is considered sacred, and part of the tree was used as an heirloom object by pilgrims visiting the forest area.

Leuweung Sancang Nature Reserve has a reasonably extensive mangrove ecosystem of around 2,157 ha, so it has the potential to supply natural fabric dyes. The types of mangrove plants found are at least eight species from five families, as shown in Table 1.

Table 1. Types of mangrove forest vegetation in Leuweung Sancang Nature Reserve

Local Name	Scientific Name	Family
Bakau	<i>Rhizophora mucronata</i>	<i>Rhizophoraceae</i>
Bakau	<i>Rhizophora apiculata</i>	<i>Rhizophoraceae</i>
Mangrove Hitam	<i>Aegiceras corniculatum</i>	<i>Myrsinaceae</i>
Nyirih/Granat/Bogem	<i>Xylocarpus granatum</i>	<i>Meliaceae</i>
Tancang	<i>Bruguiera gymnorizha</i>	<i>Rhizophoraceae</i>
Api-api	<i>Avicennia marina</i>	<i>Avicenniaceae</i>
Pedada	<i>Sonneratia alba</i>	<i>Sonneratiaceae</i>
Pedada	<i>Sonneratia caseolaris</i>	<i>Sonneratiaceae</i>

In Table 1, three species can be used as natural dyes for good-quality fabrics, which are presented in Table 2. Three mangrove species can generally be used as good-quality batik dyes: *Bruguiera gymnorizha*, *Rhizophora mucronata*, and *Rhizophora apiculata*. In the *Bruguiera gymnorizha* species, the plant parts used as batik dyes are the leaves that produce a yellowish-brown color (Anggryani, 2021; Risnasari et al., 2021) and the stem with a brown

color (Putri et al., 2020). While in the *Rhizophora mucronata* species, the plant parts used as batik dyes are the leaves and bark of the stem that produce a brown color (Dewi et al., 2018; Risnasari et al., 2021; Paryanto et al., 2015), and the leaves of *Rhizophora apiculata* can have a yellowish-brown color (Irawati et al., 2020; Paryanto et al., 2015).

Table 2. Types of mangrove plants in Leuweung Sancang Nature Reserve for natural fabric dyes

Local name	Scientific name	Color	Utilized parts	Reference
Tancang	<i>Bruguiera gymnorizha</i>	Yellowish-brown, Brown	Leaves, Stems	Anggryani, 2021; Risnasari et al., 2021; Putri et al., 2020
Bakau	<i>Rhizophora mucronata</i>	Reddish Brown, Light Brown	Leaves, Bark	Dewi et al., 2018; Risnasari et al., 2021; Paryanto et al., 2015
Bakau	<i>Rhizophora apiculata</i>	Brown	Leaves	Irawati et al., 2020; Paryanto et al., 2015

Compared to synthetic dyes, the advantage of natural fabric dyes is that all parts of plants utilized as dyestuff ranging from roots, stems, bark, leaves, flowers, and fruits, can be used to zero. Some of the results of mangrove plant processing for natural dyes and batik dyes such as *Rhizophora mucronate* fruit, leaves and stems of *Sorenesia alba*, *Rizophora sp*, *Avecenia sp*, *Ceripos decandra*, and *Lumicera sp* can produce dyes that do not fade quickly (Dewi et al., 2016; Dewi et al., 2018; Pringgenies et al., 2013; Pringgenies et al., 2017; Paryanto et al., 2015). Natural dyes also have low water solubility because some natural dyes do not have a solvent group (Purwar, 2016; Zamri et al., 2012). The remaining solid waste from residual boiled products can be reused as compost (Purwanto, 2018).

Potential and Social Capital for the Development of Fabric Natural Dyes from Mangroves

One of the contributors to Indonesia's exports is the creative industry, with an average contribution to the GDP of IDR 1,105 trillion or 7.44% and is projected to increase (Bekraf 2019). The patterns and characteristics unique to traditional Indonesian fabrics in the fashion field can be a distinctive feature compared to other fabrics, so this can be an additional point in the promotion of its products. If traditional Indonesian fabrics are produced and marketed correctly, they can have promising creative economy potential.

On the other hand, the traditional fabrics are one of self-identity and are a characteristic of the culture and social capital of the Indonesian people. Social capital plays a crucial role in the development of the handicraft industry, the existence of a sense of self-confidence, and the existence of values and networks that can accommodate every policy from the local government for the development of its crafts (Apriawan et al., 2020).

Batik culture in Indonesia has spread among Indonesians, especially in coastal communities in the Regions of Java, Sumatra,

Bali, Kalimantan, and Sulawesi. Based on the Ministry of Industry records, most batik fabric makers are in the Small-Medium Industry sector, which is spread across various industrial centers. The batik industry center consists of 101 centers, with a total of 3,782 business units, and absorbs a workforce of up to 15,055 people. The batik industry's center is Central Java, East Java, Yogyakarta, and West Java. Meanwhile, the number of batik industry workers in Sancang or, more precisely, in Garut City is only 100 people, divided into two jobs: painters and color givers.

The workers in the batik industry are dominated by women whose production processes are done in their respective homes. The wage system in Garut City uses a wholesale system according to the motif's difficulty level and the type of batik and weaving materials. Some people in Garut City depend on the batik industry, so batik sales are spread in several cities with an average annual production value of Rp. 30 million.

On the other hand, the economic welfare of the communities around The Leuweung Sancang Nature Reserve is relatively lacking. People's education level is generally low, and some do not have the education. Livelihoods are generally farmers and farm laborers with erratic incomes. According to the results of Wollenberg's (2004) research, rural communities around forests are often poor in Indonesia. The lack of jobs and limited agricultural land cause frequent conflicts over land encroachment in natural reserves, so the natural environment in reserves is exploited and not utilized sustainably (Hernawati et al., 2019).

In addition, a strong belief in the myth of the Leuweung Sancang Nature Reserve and the cooperation culture of the local community is an excellent social capital in developing the natural coloring of mangrove plants. People have the desire to conserve forests, but communities need cash income for their daily needs (Setiajiati et al., 2017). For this reason, developing non-timber forest products can be an alternative strategy for protecting the Leuweung Sancang Nature Reserve while making an economic contribution to the community.

The community already knows about the potential of non-timber forest products from mangrove forests, such as natural coloring and food. However, the practice of developing this potential is minimal due to the lack of mentoring and socialization. Socialization is still limited to appeals to ban mangrove destruction without being equipped with strategies to utilize non-mangrove forest products sustainably. It is understandable because the activities allowed in the Leuweung Sancang Nature Reserve are indeed for the benefit of research and development, science, education, and other activities that support cultivation (Law Number 5 of 1990 Article 17 Paragraph 1). For this reason, the community must obtain permission

from the West Java Natural Resources Conservation Center, Garut Regional Section, to take mangrove plant waste as a natural dye. The development of natural dyes for mangrove forest products can also be one of the motivations for the community to conserve mangroves outside the forest area or other use areas.

Potential and Challenges of Developing Fabric Natural Dyes from Mangrove Plants

Based on the potential, information obtained related to the strengths, weaknesses, opportunities, and threats in developing natural fabric dyes from mangrove plants are as follows [Table 3].

Table 3. The results of the SWOT analysis of the development of natural dyes on traditional Indonesian fabrics

	Strengths/S	Weaknesses/W
Internal Factors →	<ol style="list-style-type: none"> 1. Non Timber Forest Product (NTFP) potential is abundant in mangrove forests 2. Natural dyes have advantages such as being safe to use, renewable, easily degraded, and friendly to the environment 3. Natural dyes from mangroves are accessible and affordable for the community 4. The availability of stakeholders in the fabrics business 	<ol style="list-style-type: none"> 1. Deforestation and degradation of mangrove ecosystems. Also, mangrove grows very slowly 2. People's income is relatively low 3. Public knowledge about manufacturing natural fabric dyes from mangrove forests is still lacking.
External Factors ↓		
Opportunities/ O	Strategies (S-O) :	Strategies (W-O) :
<ol style="list-style-type: none"> 1. Strategic location adjacent to the center of the fabric industry (Cirebon, Bandung, Jakarta, Megamendung, etc.) 2. Advances in information and communication technology make it easier to market products. 3. The increasing recognition of batik fabrics by the international world 4. Increasing consumer demand for traditional fabrics such as batik, and weaving from natural dyes and local government regulations requiring government employees to wear batik on certain days (Qoriah, 2019) 5. The development of the Garut batik industry opens up better market opportunities 6. High domestic tourism in Sancang Village for pilgrimage or religious tourism purposes 	<ol style="list-style-type: none"> 1. Replacing synthesis dyes with natural dyes (S2, S3, O4) 2. Developing parts of mangrove plants as natural dyes with better quality (S1, S3, O4) 3. Increase the carrying capacity of the fabric industry with tool/machine investment (S4, O1, O5) 4. The need for analysis of the use of NTFP raw materials and the content of environmentally friendly compounds (S2, S3, O4) 5. Create networks or cooperation related to online and offline product marketing (S4, O1, O2, O5) 6. Collaboration with religious tour guides in the promotion of mangrove natural dye batik in Garut (S2, S4, O6) 	<ol style="list-style-type: none"> 1. Utilization of NTFP (mangroves sustainably) (W1, O4) 2. Determining the superior NTFP and designing the type suitable for the development focus (W1, W3, O4) 3. Working with relevant stakeholders to rehabilitate NTFP plantation forests (W1, W2, W3, O4) 4. Collaborating with Universities or Institutions around Garut to provide knowledge to the community on how to make natural dyes that are efficient and easy (W2, W3, O4, O5) 5. Collaborating with tool/machine provider stakeholders (W2, W3, O1, O2, O5)

Threats/ T	Strategies (S-T) :	Strategies (W-T) :
1. It takes creativity to develop traditional Indonesian fabrics and natural dyes	1. Investment for business development in the form of tools/ machines and increasing resources (S4, T1, T3, T4)	1. Companion to the community, with effective communication (W3,T1, T3, T4)
2. It needs innovation and consistency for proper production and marketing	2. Training related to the use of natural coloring agents (S2, S3, T1, T3, T4,)	2. Conduct business feasibility analysis periodically and continuously to monitor business development (W2, T1)
3. The stakeholders who facilitate the development of the industry are limited	3. Increased networking and cooperation between related parties (S4, T1, T2, T3, T4)	
4. Business networks have not been formed properly	4. Public awareness of the importance of using environmentally friendly products (S2, S3, T1, T3)	

Based on the interview's data regarding the benefit and cost of making natural dyes at household scale with the assumption shown in the methodology, the result of financial analysis is shown in Table 4.

Table 4. Financial analysis on business of natural dyes production for fabrics

Criteria	Value
NPV	IDR 831,890,154
BCR	1.2
IRR	30.77%
Payback Period	4 year

Based on Table 4, the business for mangrove natural dye fabric industry is feasible because a BCR value is greater than 1, which is 1.2; an NPV value of more than 0, which is IDR 831,890,154 and an IRR of 30.77% that greater than the interest (7%), which means very resistant to economic changes or crisis. The payback period is in the fourth year, which is relatively fast for the forestry sector. Therefore, developing natural dyeing fabrics from mangroves is worthy of effort by the community and Micro, Small, and Medium Enterprises because there is no need to wait a long time to make a profit, and it does not require significant capital.

CONCLUSIONS AND RECOMMENDATIONS

Community economic development through facilitating the development of natural fabric dyes from mangrove plants can be an alternative strategy to conserve mangrove

forests in the Leuweung Sancang Nature Reserve and its surroundings. There are at least three species of mangrove plants that can be used effectively as natural dyes for fabrics to produce brown color variants: *Bruguiera gymnorizha*, *Rhizophora mucronata*, and *Rhizophora apiculata*. Supported by the increasing development of traditional Indonesian fabrics, community culture, community motivation in increasing income, and a strategic location adjacent to the center of the fabric industry, the people of Sancang Village have the potential to develop mangrove forest products as natural dyes for fabrics. This business is financially feasible, worthy of effort by Micro, Small, and Medium Enterprises, and resistant to the economic crisis. However, some challenges include the absence of companions and stakeholders who facilitate so that the community is not yet skilled in making natural dyes and business networks that have not been formed properly. Therefore, the government, forestry extension workers, NGOs, and universities are necessary to realize mangrove conservation and influence community economic improvement.

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